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Technical News Bulletin

IGY World Warning Agency

BEGINNING July 1, 1957, the National Bureau of Standards radio forecasting center at Fort Belvoir, Va., will serve as the focal point of a worldwide communications network for the International Geophysical Year. From this point, warnings will be flashed to scientists throughout the world to redouble their observational efforts in anticipation of unusual activity in cosmic rays, aurora, earth magnetism, and radio propagation disturbances.

The warnings will be based mainly on worldwide observations of the surface of the sun and on soundings of the ionosphere, the electrically charged upper portion of the atmosphere. When the surface of the sun erupts, shooting out flames for hundreds of thousands of miles, the earth's atmosphere is showered with vastly increased quantities of particles from outer space. This solar bombardment not only causes magnetic compasses to misbehave but also produces brilliant displays of Northern Lights and causes changes in radio communication through its effect on the ionosphere.

The NBS field station has been selected as the IGY World Warning Agency by the U. S. National Committee for the IGY. Organized by the National Academy of Sciences—National Research Council, the U. S. National Committee is planning and directing United States participation in the IGY under the chairmanship of Dr. Joseph Kaplan. The worldwide warning network is under the general direction of Alan H. Shapley of the NBS Boulder (Colo.) Laboratories, who is serving as Vice Chairman of the United States National Committee for the IGY and international coordinator of IGY communications. The IGY World Warning Agency at Fort Belvoir is headed by Roger C. Moore of the NBS staff.

In addition to the NBS station at Fort Belvoir, the international network includes the radio teletype network of the World Meteorological Organization, virtually all of the commercial communications facilities throughout the world, government facilities (such as military channels and in the United States, the Civil Aeronautics Administration), and special messages broadcast by stations WWV and WWVH (on the NBS radio propagation forecast channels) and their counterparts in other countries. This elaborate and far-reaching network has been set up so that IGY scientists,

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FOSDIC II . . . reads microfilmed punched cards

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Control room of the IGY World Warning Agency. Here, during recent trial runs, radio signals from the North Atlantic area were monitored for forecasting purposes, and teletype messages were received from and sent to all parts of the world. Incoming teletype messages bring data on disturbances on the sun or in the earth's atmosphere. Outgoing messages warn IGY scientists of expected increases in geophysical disturbances. Solar data are entered on a globe representing the sun. The white chalk circles on the globe show the present location and size of sunspots.

no matter how remote the site of their work—from Arctic outposts to Pacific islands or the Himalayas—can conduct their experiments simultaneously. Since January 1957 the warning system has been undergoing a week of advance trials each month.

The International Geophysical Year of 1957–58 has been planned as a massive, coordinated assault by the scientists of the world upon the mysteries of this planet. From July 1, 1957, through December 31, 1958, several thousand scientists representing over 50 nations will make simultaneous worldwide measurements of the earth's interior, its crust, its oceans, its atmosphere, and its immediate cosmic environment. The results of this international enterprise should help answer questions as to the size and shape of the earth, how and where weather is generated, whether the world will continue to grow warmer, why the pull of gravity varies over the earth, the origins of earthquakes, and the causes of radio blackouts.

Because it is not economically feasible for scientists to make intensive worldwide observations every day during the IGY, a series of Regular World Days has been selected in advance for more detailed simultaneous observations. These Regular World Days will be supplemented from time to time by two types of warnings—Alerts and Special World Intervals—which the IGY World Warning Agency will issue when major solar-terrestrial disturbances are expected.

Alerts will be used to notify IGY scientists that a Special World Interval may be called in a few days. The Special World Interval will be called on 8 hours' notice when there is a strong possibility that a major solar-terrestrial disturbance will begin within 24 hours after the start of the interval. The interval will end when the disturbance subsides, or in about 48 hours should the predicted disturbance not materialize.

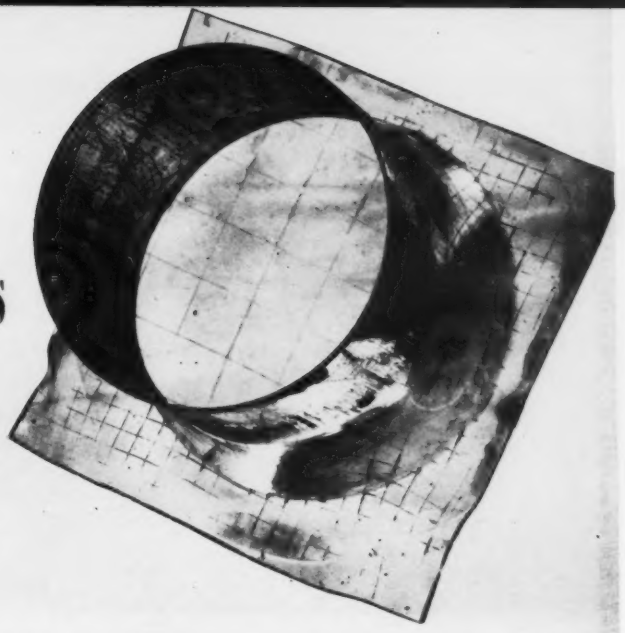
IGY programs in ionospheric physics, geomagnetism, solar activity, cosmic rays, and aurora will be intensified during Special World Intervals. Some special cosmis ray balloon flights and rocket launchings may be made during these periods, with experiments on a standby basis, awaiting notification of special conditions from the world-warning center.

Each day, by 1600 UT (Universal Time), scientists at the World Warning Agency will decide whether to call an Alert or Special World Interval for 0001 UT the following day or not. This decision will be made with the advice of ionospheric and solar observatories and communications forecasting centers both in the United States and abroad.

If solar conditions justify calling an Alert or Special World Interval, the World Warning Agency will issue messages to Regional Warning Centers in The Netherlands, France, Germany, Japan, and the USSR, and then to Associate Warning Centers in Australia, Antartica, and Alaska. From these centers, the warnings will be flashed to every IGY field station throughout the world.

The forecasting center in Virginia will also serve as the Western Hemisphere Regional Warning Center. In the United States itself messages will be put on the U. S. Weather Bureau communications system, so that all U. S. Weather Bureau stations will be alerted. It is then the task of each Weather Bureau station to inform all the other IGY field stations in its locality. The special radio propagation transmitting stations—WWV and WWVH in the United States, LOL in Argentina, and JJD in Japan—are expected to serve as a secondary method of informing the world IGY stations of Alerts and Special World Intervals.

STRETCH-ORIENTED TRANSPARENT PLASTICS FOR AIRCRAFT



TRANSPARENT ACRYLIC plastic sheeting is widely used for canopies in military aircraft because of its light weight and the ease with which it can be formed into streamlined shapes. However, disadvantages of this material have been its tendency to craze, that is, to form tiny cracks or fissures, and to shatter when subjected to gunfire while pressurized. To improve the shattering resistance, this material is often used in laminated form with a soft vinyl plastic interlayer, similar to safety glass. However, the laminate is heavier than the unlaminated form and has a greater tendency to craze.

Seeking to improve the properties of the plastic sheet, the Bureau has for several years conducted investigations [1] of the effects of stretching on acrylic plastics. Sponsored by the National Advisory Committee for Aeronautics, this work has been carried out by G. M. Kline, I. Wolock, B. M. Axilrod, M. A. Sherman, D. A. George, and V. Cohen of the NBS staff.

In July 1950, at the First Transparent Materials Conference held at Wright-Patterson Air Force Base, Dr. Kline reported that the crazing problem could be solved for acrylic aircraft enclosures by stretch orienting the plastic sheet before forming the enclosure. Further work, reported in 1951, indicated that stretched sheets of polymethyl methacrylate had greatly improved toughness characteristics. In fact, it appeared that acrylic glazing for pressurized aircraft enclosures would probably be strong enough without lamination, so that considerable weight might be saved.

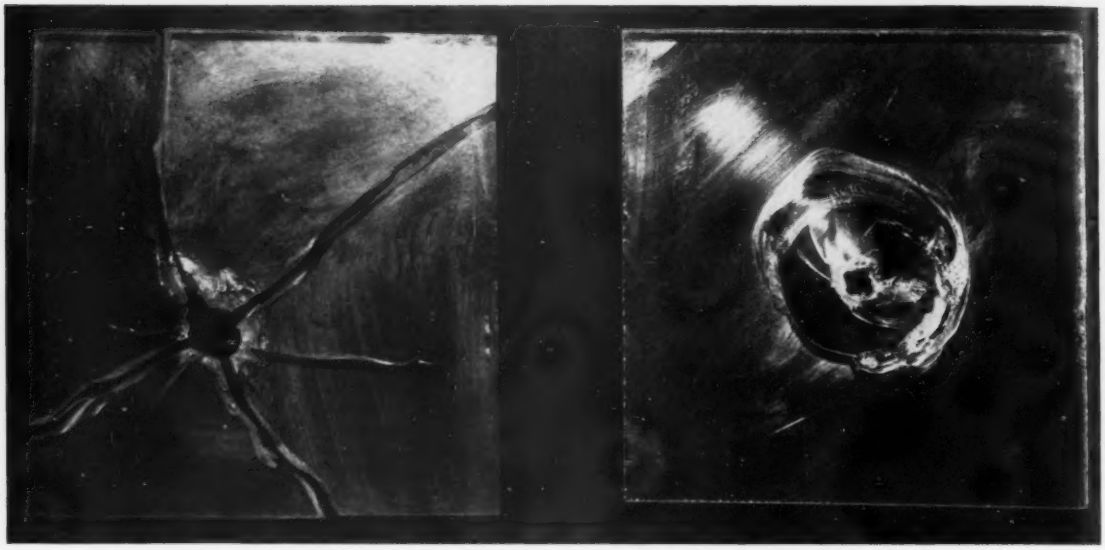
Based on these observations, widespread application of stretched acrylic glazing on aircraft has recently begun. For example, an all-weather supersonic jet interceptor is now being produced with a canopy formed of stretched acrylic sheet. And a new turboprop plane will have stretched acrylic windows which are reported to be safer and more damage-resistant than the basic airplane structure. In other aircraft, weight savings of hundreds of pounds are being achieved through use of stretched acrylic plastic.

The initial work at the Bureau on stretch-oriented plastics was done with polymethyl methacrylate sheets multiaxially stretched 50 percent. To obtain flat samples uniformly stretched in all directions in the plane of the sheet, the plastic sheet was first heated to a temperature in the rubbery range for the material. The sheet was then clamped to the open end of a flanged cylindrical vessel, the vessel evacuated, and the plastic drawn into the vessel roughly in the form of a hemisphere. A metal cylinder was inserted into the hemisphere and clamped in place, and air was admitted into the vessel. The heated rubbery plastic would retract around the inner cylinder, roughly forming a top hat.

In view of the favorable results obtained in 1950 to 1951 with polymethyl methacrylate stretched 50 percent, the effects of 100- and 150-percent multiaxial stretching on both general-purpose and heat-resistant grades of this material were studied. Resistance to crazing in short-time tests was found to increase markedly with increasing degrees of multiaxial stretching. In fact, specimens stretched 150 percent were almost completely craze resistant, even at stresses very close to the ultimate strength and in the presence of a solvent.

The threshold stress for stress-solvent crazing with benzene increased from approximately one-fourth of the ultimate strength for the unstretched material to approximately three-fourths for the 100-percent-

Photograph at top of page shows sample of formed polymethyl methacrylate as removed from stretching apparatus. Specimens to be studied are taken from the flat portion of the "top hat".



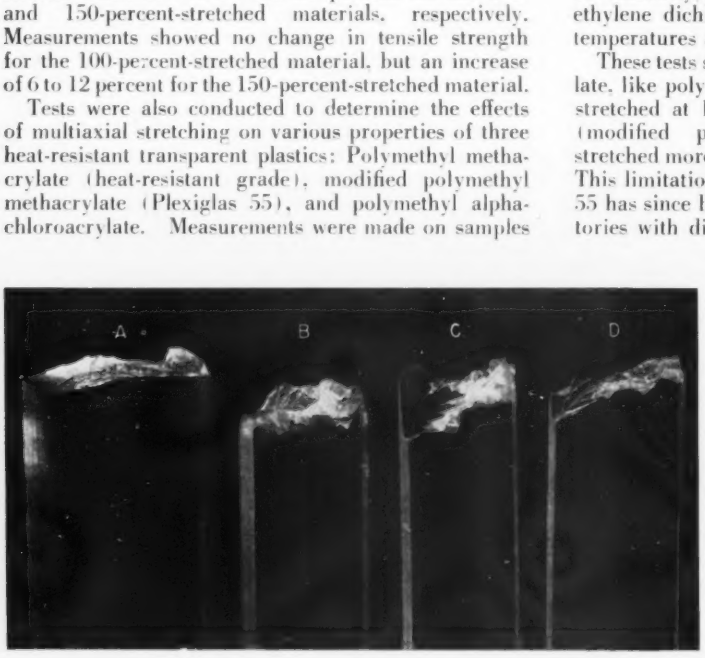
Specimens show the increased resistance of stretched-oriented to plastic shatter under gunfire. The unstretched specimen shattered into several pieces when hit, but the stretch-oriented specimen remained essentially intact except for the bullet hole.

stretched material. None of the stretched specimens crazed in the short-time tensile tests in the absence of solvent.

The strain at failure, a measure of toughness, was also increased—from approximately 7 percent for unstretched material to 50 and 25 percent for the 100- and 150-percent-stretched materials, respectively. Measurements showed no change in tensile strength for the 100-percent-stretched material, but an increase of 6 to 12 percent for the 150-percent-stretched material.

Tests were also conducted to determine the effects of multiaxial stretching on various properties of three heat-resistant transparent plastics: Polymethyl methacrylate (heat-resistant grade), modified polymethyl methacrylate (Plexiglas 55), and polymethyl alpha-chloroacrylate. Measurements were made on samples of these materials unstretched and multiaxially stretched approximately 50, 100, and 150 percent, depending upon the stretching limitations of the particular material. Properties studied were tensile strength including crazing threshold stress, strain at failure, modulus of elasticity, stress-solvent crazing resistance with ethylene dichloride, dimensional stability at elevated temperatures and resistance to abrasion.

These tests showed that polymethyl alpha-chloroacrylate, like polymethyl methacrylate, can be multiaxially stretched at least 150 percent, whereas Plexiglas 55 (modified polymethyl methacrylate) cannot be stretched more than 85 percent with the apparatus used. This limitation on the stretching capacity of Plexiglas 55 has since been borne out by studies at other laboratories with different types of stretching equipment.



Fracture surfaces of polymethyl methacrylate tensile specimens show increase in laminar structure with increasing degrees of multiaxial stretching. Specimen A is unstretched; B is stretched 50 percent; C, 100 percent; and D, 140 percent.

In all three of these plastics multiaxial stretching was found to cause large increases in resistance to stress crazing and to stress-solvent crazing. This resistance increases with increasing degrees of stretching. The increase in crazing resistance was accompanied by a large increase in the strain at failure and a slight increase in tensile strength. Little effect was noted on the tensile modulus of elasticity, but there was some decrease in resistance to surface abrasion. Annealing was found to increase the tensile strength of the stretched materials slightly, and resistance to stress-solvent crazing of both stretched and unstretched materials was usually increased markedly by annealing.

There appears to be a close relationship between crazing and molecular orientation. Thus, crazing may be assumed to start at submicroscopic flaws or weak points in which by chance the polymer chain segments are oriented normal to the applied tensile stress. With sufficient stress, a separation between portions of adjacent chains occurs, and the resulting crack grows until it reaches a region in which the polymer chain segments are oriented approximately in the direction of the tensile stress. Subsequent crack growth may involve rupture of primary valence bonds, especially if the stress is relatively high, of the order of the tensile strength.

In multiaxial stretching, the chain segments apparently turn into a position more nearly parallel to the surface, as indicated by the laminar character of the stretched material, and this angular change seems to be dependent on the degree of stretching. As the orientation increases, it may become more difficult for a submicroscopic crack to propagate through the thickness of the sheet because of the development of "cleavage" planes. The possibility then exists that, in highly formed polymethyl methacrylate, submicroscopic cracks form on the surface of a specimen when a tensile load is applied. The growth of cracks through the sheet is retarded by the planar orientation, however, and the specimen fails before the cracks become visible. Thus, in longtime tensile tests on polymethyl methacrylate stretched 50 percent, the crazing cracks, after becoming visible, grew more slowly as compared to those on the corresponding unstretched specimens.

The orientation of the multiaxially stretched material is apparent not only from X-ray diffraction measurements but also from the laminar structure of the fracture surface of a stretched specimen, as compared with the amorphous appearance of an unstretched specimen. This change from an amorphous to a laminar structure could account for the increase in tensile strength of the material stretched 150 percent.

The slight decrease in abrasion resistance on the stretched material may also be due to its laminar structure. The molecular chains oriented parallel to the surface may offer less resistance to abrasion than do the randomly oriented chains of the unstretched material.

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[1] *For further technical details, see* Development of craze and impact resistance in glazing plastics by multiaxial stretching, *by G. M. Kline, I. Wolock, B. M. Axilrod, M. A. Sherman, D. A. George, and V. Cohen, NACA Technical Report 1290 (1957)*; Effects of multiaxial stretching on crazing and other properties of transparent plastics, *by I. Wolock and D. A. George, NACA Research Memorandum 54F22 (1954) and SPE Journal* **12,** 20 (1956); Effects of high degrees of biaxial stretch-forming on crazing and other properties of acrylic plastic glazing, *by I. Wolock, B. M. Axilrod, and M. A. Sherman, NACA Research Memorandum 53D14 (1953) and Modern Plastics* **31,** *128 (1953)*; *and* Effects of moderate biaxial stretch-forming on tensile and crazing properties of acrylic plastic glazing, *by B. M. Axilrod, M. A. Sherman, V. Cohen, and I. Wolock, NACA Technical Note 2779 (1952); and J. Research NBS* **49,** *331 (1952) RP2369.*

A sheet of plastic aircraft glazing stretch formed in the shape of a top hat being removed from a vacuum forming vessel. The transparent plastic sheet is still attached to the form on which it was shaped. By this technique, a flat sample, stretched uniformly in all directions in the plane of the sheet, is obtained from the top of the "hat".

Very-Low-Frequency Symposium

NEARLY 300 physicists and radio engineers representing several countries convened at the Bureau's Boulder (Colo.) Laboratories January 23–25 to attend a symposium on "The Propagation of Very-Low-Frequency Radio Waves." The symposium was sponsored by the Boulder Laboratories and the Professional Group on Antennas and Propagation of the Institute of Radio Engineers. Papers and discussions during the 3-day meeting centered on general and theoretical problems, waveforms of atmospherics and whistlers, and systems and communications.

The symposium was concerned with the very narrow but extremely important low-frequency band of the radio spectrum from 3 to 300 kc. This region is particularly suited for use in navigation systems, long-distance communication, and for the precise measurement of radiofrequencies, as well as for numerous basic research endeavors.

After introductory remarks by Dr. F. W. Brown, Director of the Boulder Laboratories, the symposium opened with an address by Prof. A. H. Waynick, Director of Ionosphere Research Laboratories, Pennsylvania State University, on "The Present State of Knowledge Concerning the Lower Ionosphere." Banquet speaker was Commander Lyle Read, Navigation Program Officer at the U. S. Navy Electronics Laboratory, San Diego, who described the shortcomings of present navigational aids used in aeronautics. Commander Read said that a successful modern air navigation system would probably depend upon an understanding and knowledge of low-frequency transmission and propagation of radio waves.

In a talk jointly sponsored by the Boulder Laboratories and the Denver-Boulder chapter of the Institute of Radio Engineers, Dr. K. G. Budden of the Cavendish Laboratory (Cambridge University, England) described ionospheric research on long waves at Cambridge.

Theoretical papers occupied the first day's session during which considerable interest was shown in papers on very low-frequency radio wave propagation over long distances.

James R. Wait, chairman of the symposium and consultant at the Boulder Laboratories, discussed extensions to the geometrical optics of VLF sky-wave propagation in collaboration with A. Murphy, also of NBS. The theory is based on the fact that low-frequency radio waves arrive at the receiver partly by traveling along the ground and partly by being reflected any number of times from the ionosphere. On this basis, the strength of each of these waves and of the final received combination can be predicted. Out to a distance of 1,500 km the ground and sea appear to have almost perfect conductivity but beyond, the effects of imperfect ground conductivity must be considered. In this paper, the ionosphere was taken to be a homogeneous ionized medium with a sharp lower boundary. The reflection coefficient, a function of angle of incidence, was utilized to compute the strength of the single and multiple hop sky waves. Combining these with the numerical results of the amplitude and phase of the ground wave, the total field was obtained.

Also presenting a mode theory of very-low-frequency ionospheric propagation for finite ground conductivity, Dr. Wait explained that the space between the earth and the ionosphere can be considered to act as a waveguide with sharply bounded walls. Employing a representation in terms of spherical wave functions of complex order, he calculated the field of a vertical dipole source for very-low frequencies. He showed that the effect of the finite ground conductivity is quite significant for propagation to great distances. H. H. Howe of the Boulder Laboratories explained the mode calculations done in collaboration with Dr. Wait.

A paper delivered the same day by J. L. Heritage and S. Weisbrod of Smyth Research Associates, and J. E. Bickel of U. S. Navy Electronics Laboratory, on a study of signal-versus-distance data at VLF showed agreement with both of the theories presented by Wait and was particularly important in showing where the work on the theories should next proceed.

A report on a study of a 16-kc signal received from England, considered as a standard frequency source, indicated that a single source of frequency can be made available at VLF on a worldwide basis. J. A. Pierce of Cruft Laboratory at Harvard University, author of this study, said that accuracies exceeding 1 part in 10^{10} are consistently obtained by observation over several hours. At a distance of 52 km the Doppler effect in transmission seldom exceeds ± 3 parts in 10^9, and a measurement can be made to 1 part in 10^9 in 15 min.

A low-frequency standard was also discussed in a later paper by W. D. George, Acting Chief of the Boulder Laboratories Radio Standards Division. He presented a proposal for a VLF standard frequency broadcast station now under consideration by NBS. He described results of an experimental 60-kc broadcast from Boulder which has been monitored by Pierce at Harvard. This broadcast indicates that the basic standard of frequency can be distributed in the low-frequency range with less loss of accuracy than is now achieved.

Discussion and papers on "whistlers", "dawn chorus", and other atmospheric noises occupied the second day of the symposium. R. M. Gallet of the Boulder Laboratories and R. A. Helliwell of Stanford University presented a theory of the production of VLF noise, the so-called dawn chorus, by traveling wave amplification in the exosphere of the earth.

During periods of magnetic disturbance and auroral activity there can frequently be observed a hissing sound in the output of a high-gain audioamplifier connected to a loop or long-wire antenna. The hiss is a band of noise which may extend from 1 to 10 kc or

higher and is occasionally accompanied by one or more discrete tones in this range of frequencies. It is frequently accompanied by the dawn chorus, which is a combination of short (0.1 to 0.2 sec) rising whistles and warbling tones. The frequency of occurrence of these signals appears to be greater the closer one gets to the auroral zone, although they have been observed as low as 44° geomagnetic. These phenomena have been reported for many years but practically no systematic study has been undertaken.

In their paper, Helliwell and Gallet suggested a mechanism for the generation of hiss and constant tones based on selective traveling-wave amplification of noise energy arriving from the sun or elsewhere, and suggested its extension to the dawn chorus. Energy for the amplification process is provided by streams of ionized particles which come from the sun and travel along lines of the earth's magnetic field. They are assumed to penetrate the ambient ionization of the outer ionosphere with little relative interaction. The mechanism of amplification is assumed to be similar to that in ordinary traveling wave tubes, except that the "slow wave" circuit (provided by the helix in the tube) is the ambient ionization of the outer ionosphere in the presence of the earth's magnetic field. In such a dispersive medium, the velocity of the electromagnetic wave is a function of frequency and may be reduced as much as two orders of magnitude or more below the velocity of light. Furthermore, the *energy* tends to travel in the direction of the particle stream as a result of the guiding action of the earth's field.

If this new application of the theory of traveling wave amplification, which has previously been restricted to microwave use, is correct, it will provide a powerful new tool for the study of the outer ionosphere and the hitherto immeasurable radiation from the sun.

Using information from whistlers, Mr. Helliwell and R. L. Smith described a way of estimating the amount of ionization outside the ionosphere. Data required are the apparent dispersion of the whistler and its time delay relative to the causative impulse. In interpreting middle-latitude whistlers by a two parameter method, they found that the effective latitude of the path and one parameter describing the electron density can be found. Application of the method to an actual whistler gives an average electron density of 3,700 $cm.^3$

J. M. Watts of the Boulder Laboratories called attention to a hiss that seems to coincide with geomagnetic activity. Heard particularly during periods of sunspot activity, the hiss should be considered an important tool in the study of the effects of solar emissions upon the earth.

During the third day of the symposium, H. A. Wheeler of Wheeler Laboratories (Great Neck, N. Y.) aroused much interest with a paper of the difficulties of radio reception in a submerged submarine. A submarine requires a small VLF antenna for reception while submerged. Because the propagation in sea water is nearly vertical (downward from the surface) the only operative types are horizontal dipoles, electric and magnetic. The electric dipole is coupled by conduction and the magnetic dipole by induction in a loop. The former has no resonance and nearly unlimited bandwidth, but fails when not submerged. The latter, by resonance, is able to present much greater interception area and available power. The magnetic interception area is determined by the size of the radome and by the radian length or skin depth in sea water (2 m at 15 kc). The radiation power factor (which is essential to bandwidth and efficiency) is influenced also by the size of the inductor and by the magnetic permeability of an iron core. Mr. Wheeler presented simple formulas illustrating these relations for the idealized spherical shape of radome, coil, and core.

In another paper on practical application, H. G. Wolff of the U. S. Navy Electronics Laboratory in San Diego described a new method of transmitting teletype or high-speed Morse signals that results in speeds of 100 words per minute or more. This is in contrast to present VLF transmission speeds of only 20 words a minute due to the bandwidth limitations of the high-Q antenna circuit.

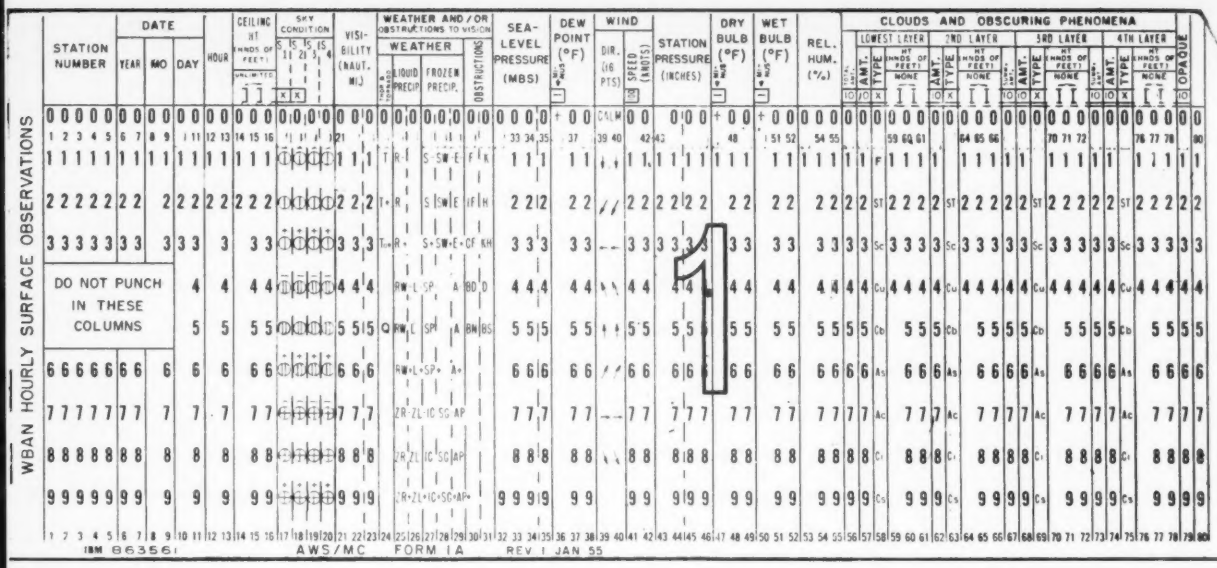
The new method makes use of variation of the reactance of the antenna circuit in synchronism with frequency shift modulation of the carrier. The increase in transmission speed by a significant factor in present traffic handling capabilities of VLF stations can be accomplished by increasing the cost of the station less than 10 percent.

A total of 45 papers was delivered. A limited number of the symposium proceedings are now available upon request from the NBS Boulder Laboratories.

Bibliography on Nitrogen–15

THE analysis of nitrogen, one of nature's most abundant elements, is important in biology and medicine as well as a wide variety of other fields. The Bureau has recently published a literature survey on the nitrogen isotope N^{15}. This survey grew out of a project sponsored by the Atomic Energy Commission to extend the optical spectroscopic method of isotope analysis to the measurement of N^{15}/N^{14} ratios. The references, which are not definitive, cover the period from 1919 to 1952, inclusive, with some later references. The citations are grouped by subject and relate to the abundance of N^{15} occurring naturally, its physical properties, methods of concentrating it, methods of measuring N^{15}/N^{14}, and the synthesis and use of N^{15} compounds.

This publication, entitled *Bibliography on Nitrogen–15*, by Margaret W. Chapman and Herbert P. Broida, National Bureau of Standards Circular 575, issued October 1, 1956, 12 pages, 15 cents, is available from the Government Printing Office, Washington 25, D. C.



FOSDIC II—Reads Microfilmed Punch

THE NATIONAL BUREAU OF STANDARDS has completed FOSDIC II—a high speed electronic device that can read microfilmed copies of punched cards and search for cards containing specific information. FOSDIC II (Film Optical Scanning Device for Input to Computers) is an extension of the work that resulted in the original FOSDIC, a device to read microfilmed Census documents.[1] Sponsored by the Weather Bureau, the present machine is designed to aid in the high-speed processing of weather data contained on over 300 million punched cards at the Weather Records Center in Asheville, N. C. It is essentially an electronic scanner which reads filmed images of these punched cards, searches for cards containing specified information, and copies the selected information onto new cards for computer input. The device was developed by M. L. Greenough and E. C. Palasky of the Bureau's electronic instrumentation laboratory to link large files of permanent data on punched cards with automatic data processing equipment.

In maintaining punched card files, the cost of storage and the difficulties of preservation have always been pressing problems. Cards are subject to handling damage and individual loss, and the paper stock itself deteriorates in inactive storage. Moreover, with extremely large quantities of cards, access to the information contained on them is time consuming. Through the use of microfilms of the punched cards, together with FOSDIC II to rapidly recover the data, (1) file storage space can be reduced by a factor of over 100, (2) the searching logic permits a high degree of selection, (3) duplicate files can be easily and economically prepared, (4) visual inspection of the data content and condition of the storage file is readily apparent with a microfilm viewer, and (5) data can be preserved almost indefinitely. Chiefly for these reasons, microfilm was selected as the new storage medium rather than magnetic tape.

The central element of FOSDIC II is the electronic scanning assembly. Light from the screen of a cathode-ray tube is focused upon the microfilm image, and the transmissivity of small, discrete areas on the film is measured by a photoelectric cell. By moving the electron beam around on the face of the cathode ray tube, any selected area of the image may be examined. Control of the position of the illuminated area, and interpretation of the photoelectric signals, are functions performed by the associated electronic circuitry. Through positional control, or scanning, the point of light travels in prescribed manner from one point to the next in turn.

Because there is only one electron beam in the cathode ray tube, the scanning style is serial in its time sequence. With this serial method, only a few circuits are used repeatedly, rather than the converse as for a parallel or multiple-sensing approach. As a result, for the same amount of equipment, it is possible to emphasize refinement of performance rather than speed. However, FOSDIC II is still many times faster than mechanical card handling machines.

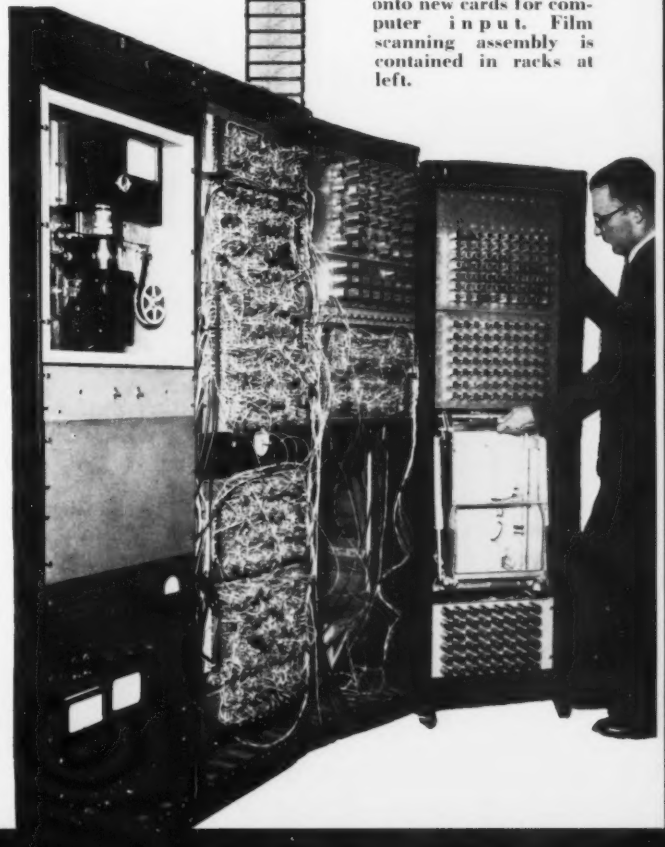
The input to FOSDIC II is in the form of 16-mm microfilm. Each 100-ft roll contains up to 13,000 images of punched cards. Although the present equipment is designed for the 80-column, rectangular-hole card, it could be modified to work equally well for the 90-column, round-hole card. The film is currently

edPunched Cards

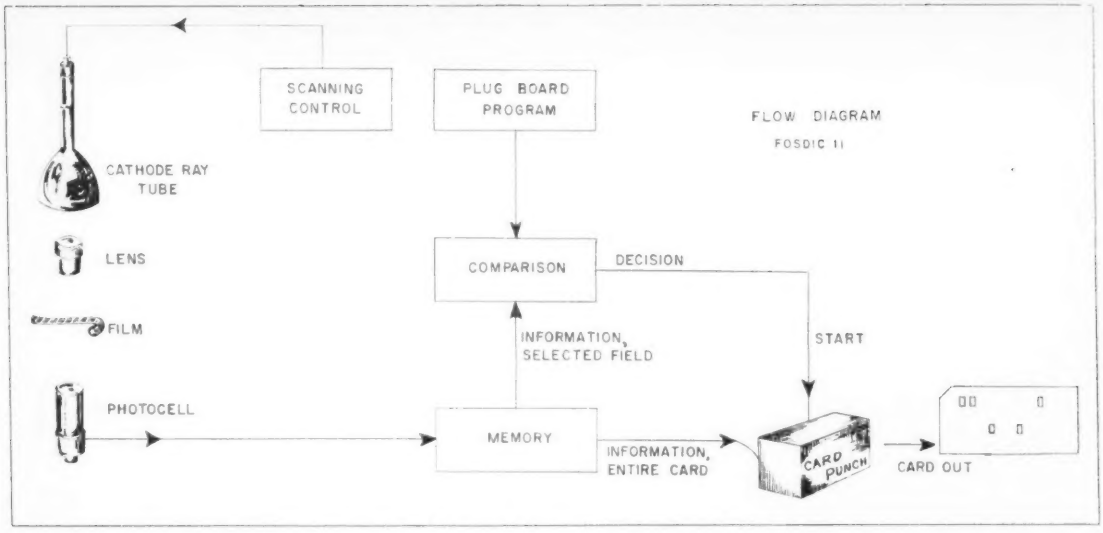
prepared in a special microfilm camera designed and built at the Bureau of the Census. This camera films the cards against a background scale which provides the indexing for the columns on the card. Whereas the nominal reduction ratio is 24:1, a considerable tolerance exists because the scale is included on the film. The reduction ratio is made greater by a factor of two in the short dimension of the card by an anamorphic lens attachment in the camera. The rectangular punched holes on the card thus appear as squares on the film and can be read just as easily by the machine. Through the use of this lens, nearly twice as many cards can be included in a roll of film.

In operation, the machine searches for images to match previously programed information. Program control is through a plugboard into which the desired selection logic has been wired. To meet the particular requirements of the contemplated service, card selection is based upon the contents of 10 of the 80 columns; this capacity could be expanded by the addition of more memory components. The selection is not limited to unique patterns; with the available logical "and" and "or" elements, a wide range of variables and conditional acceptances can be specified.

To increase speed, the film is read while in motion with a synchronized scan. As it passes by the scanning head, the 10 selected columns in each image are read and the results stored in a memory of 120 bits. At the end of the scan, the memory contents are compared to the plugboard pattern. When agreement is found, a rapid-response brake stops the film, leaving the selected image within the field of view. The image is then scanned again in its entirety, feeding a reproduc-



Left: **Full-size reproduction of punched card microfilm. Even though the holes are barely visible to the naked eye, FOSDIC II can detect them rapidly and accurately. About 13,000 cards can be included on one 100 ft roll of film.** ***Below:*** **Electronic circuitry of FOSDIC II scans microfilmed images of punched cards, searches for card images containing specified information, and copies the selected information onto new cards for computer input. Film scanning assembly is contained in racks at left.**



Flow diagram of FOSDIC II. Information from first 10 columns of microfilmed punched card is sent into memory where it is compared with preprogramed information. If information does not match, memory is canceled and scanning assembly goes on to read next card. If information does match, all data on card are read into card punch, where duplicate card is made. Machine then reads next card.

ing card punch to create a new card identical to that on the film. Thereafter the searching process resumes until the next match occurs. Searching rate is over 4,000 cards per minute for a 10-column field, but readout to the card punch is reduced to 100 per minute to match the speed of the mechanical punching machinery.

As the search begins, the flying spot proceeds vertically along the index mark side of the card. The interruption of light transmission on reaching the index mark indicates the presence of a card and causes the spot to travel to the right across the column index scale. When the column index count reaches a selected column, the flying spot stops its horizontal motion and drops vertically toward the edge of the card image. The top edge of the card is used as a base for locating the 12 positions below in which it might be possible to find a punched hole. When the edge is found, the flying spot jumps successively to the 12 row positions and pauses in each, while associated circuitry samples the photocell output to determine whether a hole or an opaque area exists in that location. The presence of punched holes, if any exist, is registered in a synchronized memory.

When the light spot returns to the column index level, it moves horizontally, searching for the next column of interest. At each selected column the examination procedure is repeated. After the spot has completely scanned the card image area, it returns to the index side of the card and waits while the information contained in the memory is compared with the specifications from the plugboard. If the specifications are not met, the spot moves vertically along the index mark side of the cards, seeking the next card. On the other hand, if the document content does meet the specifications, the film immediately stops and the associated card punching machine is turned on.

The entire image is read out while stationary. FOSDIC reads the film, row by row, in the proper order while maintaining synchronization with the card punching machine. This general method of extracting the information is closely allied to the method of searching. The card is located by the same procedures, but in seeking columns the machine assumes it is interested in all columns. However, it examines only one row at a time in each column. The contents of that row are registered in the memory and FOSDIC waits until the card punch extracts this information. Immediately after the information is called for, FOSDIC scans the document again looking only at the next row. This is repeated until all 12 rows have been presented to the punch.

It is expected that FOSDIC II will be followed by similar instruments for reading information contained on microfilm images. There is good evidence that the searching speed of the present device, for instance, can be raised considerably without appreciable loss of reliability. Aside from faster versions, there is the possibility of modifying these scanning techniques to provide an information retrieval machine that searches filmed documents accompanied by coded punched cards. Photographic, rather than electrical, copying of the data might then be employed.

[1] FOSDIC—A film optical sensing device for input to computers, *NBS Tech. News Bul.* **38**, 24 (Feb. 1954).

NEUTRON PHYSICS SECTION ESTABLISHED

A NEUTRON PHYSICS SECTION has been established in the Bureau's Atomic and Radiation Physics Division. Under Randall S. Caswell as its Chief, the section will be responsible for the design, development, maintenance, and calibration of neutron standards, and for the calibration and certification of neutron sources. In carrying out these responsibilities, the section will undertake research on the properties and characteristics of neutrons, make studies on neutron shielding and dosimetry, and engage in the development of new or improved techniques and instrumentation for neutron detection and measurement. Research on neutron properties and characteristics will include investigations of neutron spectra, elastic and inelastic scattering cross sections, attenuation, and the like. This program includes some of the activities of the former Neutron Measurement Section.

The neutron, one of the constituents of atomic nuclei, was discovered by Chadwick in 1932, and is the key particle in the production of nuclear energy by uranium fission. The rapid growth of the nuclear energy industry has led to a need for accurate measurements of the intense neutron radiation that accompanies reactor operation. Such measurements are used in the control and operation of nuclear reactors and for protection of persons who work near all kinds of neutron sources. Expanding nuclear energy facilities have also stimulated a need for improved understanding of the interaction of neutrons with matter. This is required for more efficient design both of nuclear reactors themselves and of the protective shielding around them. In addition, because of its lack of electrical charge, the neutron is in wide use as a tool for the study of the unsolved problems of nuclear forces and the structure of the nucleus.

Neutrons for this research at NBS are provided by nuclear reactions produced with a 2-million-volt Van de Graaff accelerator and by a variety of radioactive neutron sources. Most neutron sources produce simultaneously neutrons of a wide range of energies. However, certain of the reactions using the Van de Graaff accelerator have the great advantage that the neutrons produced are of only one energy. These neutrons can be used, for example, to learn how the response of a neutron detector changes with energy or to study the penetration of neutrons as a function of energy.

The Bureau maintains two types of neutron standards. The first type are standard radioactive neutron sources. Sources sent by universities, Government laboratories, and industrial firms to NBS for calibration as laboratory standards are calibrated against the NBS standard sources by means of the activation of a manganese sulfate bath or by relative thermal neutron flux measurements in a standard graphite pile. The second type includes standards of thermal neutron flux (in neutrons per square centimeter per second). An unknown thermal neutron flux (in a nuclear reactor, for example) may be calibrated by activation of gold foils in the unknown flux and in the NBS flux.

One of the chief interests of the Neutron Physics Section is in simple, fundamental experiments on the penetration of neutrons through matter. These experiments, using monoenergetic neutron sources in simple geometries, are used to test theoretical calculations of neutron shielding. These theories are then used in the design of neutron shielding and of nuclear reactor cores. As an example of the importance of this kind of work, the chief problem in the design of a nuclear-powered aircraft is the weight of the radiation shield.

The interaction of neutrons with individual nuclei is described in terms of neutron cross sections, which are measures of the probabilities of certain neutron interactions. Determination of cross sections is important both for the understanding of the nucleus and for the prediction of neutron behavior in many sorts of practical problems. The present program is directed toward the study of neutron scattering cross sections through millimicrosecond time-of-flight techniques.

Neutrons are in general more difficult to detect than charged particles and photons. The Neutron Physics Section is studying the problems of neutron dosimetry (for protection of persons near neutron sources) and of fast neutron spectroscopy. The need for neutron dosimetry was tragically demonstrated several years ago when a number of cyclotron workers in the United States and Europe developed cataracts from overexposure to fast neutrons.

TESTING OF WEIGHING EQUIPMENT REPRINTED

Handbook 37, long a standard reference in the field of weights and measures, has been reprinted because of public demand.[1] It is one of a series of handbooks designed to present in compact form comprehensive information relative to weights and measures supervision. H37 also describes various types of scales and weights, the principles of their operation, and methods for their inspection and test.

Although this handbook was prepared primarily for use by weights and measures officials of the States, counties, and cities, much of the information presented also has proven to be of interest and assistance in maintaining weighing equipment in commercial and industrial establishments.

[1] Testing of Weighing Equipment, *National Bureau of Standards Handbook 37, by Ralph W. Smith, reprint, 184 pages, $2.50, is available from the Government Printing Office, Washington 25, D. C.*

DIRECT MEASUREMENT OF TIRE OPERATING TEMPERATURES

THE BUREAU has developed a precise, direct method for determining tire operating temperatures. The procedure involves the use of a copper-constantan thermocouple inserted through the tire valve.[1] When the tire is rotated under load, the thermocouple gives a precise measurement of the average contained-air temperature. Intended for tire research and evaluation studies, the procedure was developed by G. G. Richey, R. H. Hobbs, and R. D. Stiehler of the Bureau staff and sponsored by the Federal Facilities Corp., Office of Synthetic Rubber.

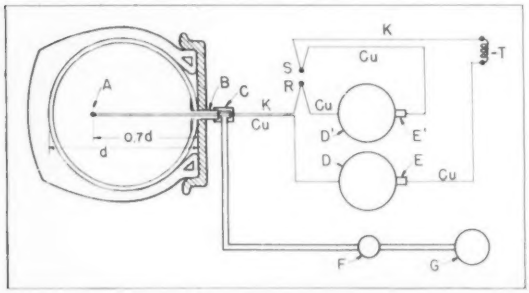
The operating temperatures of tires are of interest to tire engineers because high temperatures are caused, at least in part, by power loss. Besides, high temperatures affect the service life of tires and hence, the choice of materials used in them. For example, excessive temperatures cause the rubber to break down. As a result, the tire cords may slip and break, or hot spots—sites of potential blowouts—may be produced.

Several methods have been used to determine tire operating temperatures, but in general these methods have been difficult to carry out or have been of questionable accuracy. The most accurate procedure for determining tire operating temperature involves computation from observed pressure and volume changes. However, this procedure requires the use of a high-precision gage and, because of complex correction determinations, is very time consuming. A less complicated method in which a thermocouple is vulcanized in the tire tread, has been unsatisfactory because the thermocouple often breaks when the tire is flexed. In a third method, a thermocouple is inserted in the tire tread after the tire has stopped rotating. However, the Bureau's study has shown that when a tire is stopped abruptly, the distribution of temperature shifts rapidly in a complicated fashion. Thus, the results given by the latter method are not sufficiently accurate.

In order to determine the exact temperature of different regions of air within a tire, the Bureau conducted several experiments, each using a different thermocouple arrangement. In each series of tests, the tire contained-air temperatures were measured at speeds of 10, 30, and 50 mph while the tire, inflated to a pressure of 65 psig, supported a load of 2,875 lb. The tire tread was in contact with a steel drum 17.6 ft in circumference and 14 in. wide. The ambient temperature was maintained at 100°F (the temperature of a hot summer day). Measurements were made at each of the three speeds after steady-state conditions had been reached.

Inserting copper-constantan thermocouple in valve stem of a truck tire prior to measuring the tire's operating temperatures. The thermocouple and adapter rotate with the tire, and are connected to a stationary circuit containing the temperature recorder.

In one experiment, a differential thermocouple, mounted on a small wooden rod, was placed inside the tire so that the junctions were ½ in. and 7½ in. from the base of the valve stem. In another setup, the distances of the thermocouple junctions from the valve stem were 1 in. and 7 in., respectively. Thus, in the first case the tire operating temperatures ½ in.



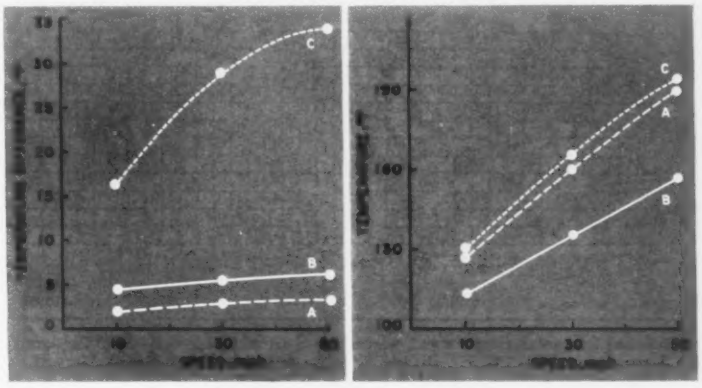
Schematic of NBS arrangement for measurement of air temperature and pressure of a rotating truck tire. A, copper-constantan thermocouple; B, valve stem; C, adapter; D, D', copper sliprings; E, E', copper-graphite brushes; F, rotating joint; G, precision air pressure gage; R, rotating copper-constantan thermocouple; S, stationary copper-constantan thermocouple; T, temperature recorder; Cu, copper lead wire; K, constantan lead wire.

from the tire casing were measured, and in the second case the temperatures 1 in. from the inner casing were measured. A third set of thermocouples was placed in the crown and base of the tire tube by inserting them through the valve and vulcanizing them in place. In another test, a thermocouple 15 in. long was inserted through the valve stem and held against the crown by centrifugal force, thus measuring the temperature of the inner tube at the crown. In addition, the contained-air temperatures were calculated for each setup according to the observed pressure and volume changes.

Temperature measurements obtained by these methods demonstrate that the temperature indicated by a thermocouple inserted 70 percent of the tire diameter (or a distance of 6½ in. for a 9.00–20 truck tire) is the average temperature of the air in the tire. The actual distance of 70 percent of the inside height was chosen to minimize the effect of radiation from the walls and thermal conduction along the wire. The air temperature is substantially the same throughout the torus of air 1 in. from the tube walls. However, close to the base of the tire, there are sharp differences.

The results of the Bureau's measurements are summarized in table 1. The mean of the thermocouple-determined temperatures and the mean of the calculated temperatures for each speed condition agree well within 1 deg Fahrenheit. The difference between the decreasing and increasing speed conditions indicates that steady state conditions had not quite been reached when the measurements were taken. However, steady state was assumed when the change in air pressure did not exceed 0.1 psi in a 10-min. period.

In order to evaluate measurements taken by a thermocouple inserted in the inner tube, the Bureau first examined the contained-air temperature pattern of a rotating tire that is abruptly stopped. A thermocouple was inserted with junctions ½ in. and 7½ in. from the valve stem. The tire was run until steady-state was obtained and then stopped and turned manually through four 90-deg positions. After 5 min a difference of 16.5 deg F between the crown and base was observed at one of the positions, indicating that measurements after the tire stops do not accurately reflect the average contained-air temperature of the tire.



Left: **Temperature differences in air and between crown and base of inner tube of a truck tire. Curve A, difference in air temperature between 1 in. and 7 in. beyond bottom of valve stem. Curve B, difference between ½ in. and 7½ in. beyond bottom of valve stem. Curve C, difference in temperature between crown and base of inner tube.** ***Right:*** **Temperature in the inner tube of a truck tire. Curve A is the average temperature of the air. Curve B, temperature at the base of the tube. Curve C, temperature at the tube crown. Studies showed that a thermocouple inserted to 70 percent of the tube inner height gives a precise measure of the average contained-air temperature.**

TABLE 1. *Pressures and temperatures of air in the inner tube of a 9.00 by 20, 10-ply rating truck tire*

(Load—2,875 lb, initial inflation pressure—65 psig at 100° F, thermocouple inserted—6½ in.)

Speed ..... mph	10	30	50
Decreasing speed condition			
Observed pressure ..... psig	68.80	73.55	77.85
Calculated temperature ..... °F	127.5	162.0	192.5
Observed temperature ..... °F	127.5	161.5	191.0
Increasing speed condition			
Observed pressure ..... psig	68.70	73.25	77.25
Calculated temperature ..... °F	126.5	159.0	188.5
Observed temperature ..... °F	126.5	159.5	189.5

Differential thermocouples used in these studies were operated through copper sliprings to a stationary copper-constantan circuit. Compensating junctions permitted the use of a copper lead wire from the constantan part of the thermocouple to its corresponding slipring and brush. The negligible potential at the sliprings was verified by a benzoic acid standard reference cell.[2]

[1] *For further technical details, see* Temperature studies of the air in a truck tire, by *G. G. Richey, R. H. Hobbs, and R. D. Stiehler, Rubber Age,* **79,** *273 (1956), also* Studies of tire performance, *NBS Tech. News Bul.* **36,** *88 (1952).*

[2] *F. W. Schwab and E. Wichers, J. Research NBS,* **34,** *333 (1945) RP1647.*

Economy in the Planning of Experiments

ONE OF THE TYPICAL PROBLEMS confronting both the experimental scientist and research worker in industry is that of evaluating the joint effects of several different factors on a given material or process. Other things being equal, the smaller the number of factors the fewer the difficulties encountered. Because of possible complex interactions among the various factors, however, the difficulties become formidable for even a relatively moderate number of factors. Problems of this kind have often had to be dismissed as too difficult, although occasional brilliant results were achieved by scientists gifted with unusual insight or sound judgment gained through long experience. The recent growth of the subject of experiment design has occurred in response to the need for more systematic and reliable methods, a need created by the growing scope and complexity of scientific and industrial activity.

One way to approach a multifactor problem is to make measurements with all factors except one fixed, and afterwards to repeat this process for each of the factors. Conclusions are then drawn concerning the effect that each factor has on the measurements. When the various factors are interdependent, however, the "one-factor-at-a-time" procedure may lead to erroneous results. R. A. Fisher [2] has shown that the most efficient way to conduct multifactor experiments is to make measurements at all possible combinations of the factors involved.

Nevertheless, even for a relatively small number of factors, the number of possible experimental combinations may more than tax the available facilities. Also, in many situations it is not practical to plan an entire experimental program in advance, but rather to conduct a few smaller experiments that serve as a guide to future work. Or, more generally, it may be that not

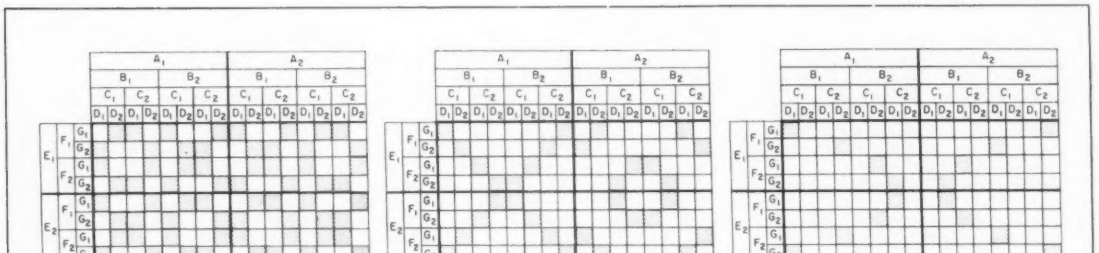


FIGURE 1

FIGURE 2

FIGURE 3

Fractional factorial experiment plans for a situation involving 7 factors (denoted by A to G) each capable of taking on 2 conditions (A_1, A_2, B_1, B_2, etc.). If every possible combination of factors and conditions were investigated, 128 experiments would be needed. Each such combination is represented by a square in the rectangular parts of the diagrams; shaded squares indicate the combinations to be used for each of the 3 experiment designs. Figure 1 requires only 64 of possible 128 experiments, figure 2 only 32, and figure 3 only 16. Which design is to be used will depend on the amount and precision of information desired, as well as on considerations of time and expense.

The first broad classes of experiment designs, made possible by advances in statistical theory, were devised to fit the special problems of agricultural research. Somewhat later, efforts were made to adapt these experimental procedures for use in physical science, engineering, and industry. At the Bureau, the study of these problems forms a major part of the research program of the NBS Statistical Engineering Laboratory. The latest results obtained by the laboratory, in research supported partly by the Chemical Corps, Department of the Army, should lead to material savings in time and effort for experimenters faced with multifactor problems. These results, which relate to an important class of experiment designs, are described and catalogued in the NBS publication, *Fractional Factorial Experiment Designs for Factors at Two Levels*,[1] all of the information or precision which a complete set of experiments could give is needed for the purpose in hand.

Several statisticians, notably Finney and Kempthorne,[3] have recently considered the problem of planning multifactor experiments that require measuring only a fraction of the total number of possible combinations. The experiment designs that have resulted are known as "Fractional Factorial" designs. These not only save experimental effort, but they also make the analysis relatively straightforward.

The result of the Bureau's studies along these lines has been to make the theory of fractional designs more immediately accessible to the working scientist. The new publication, prepared by the Statistical Engineering Laboratory (see footnote 1), catalogues experiment

designs in which the number of factors range from 7 to 16, with all factors allowed two different conditions. For problems with these general characteristics, the experimenter can choose from among procedures requiring only $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, $\frac{1}{128}$, or $\frac{1}{256}$ of all possible experimental combinations.

An industrial chemical process, for example, may depend on the commercial grade of the principal reactant, the source from which the reactant is obtained, the amount and concentration of acid used, and the pressure, temperature, and time of reaction. Suppose it is desired to study the effects on the characteristics of the final product when these seven factors are varied; and assume that it is sufficient to consider only two alternatives in connection with each factor, so that there are two commercial grades of reactant, two concentrations of acid, and so forth. Because there are seven factors and each may exist in two different conditions, there are 2^7 or 128 possible experimental combinations. A "complete factorial design" would prescribe the making of all 128 of these experiments.

However, it may not be practical to perform all of the experiments. Possibly, also, one may not need all the information such a complete factorial procedure could provide. It is at this point that assistance may be obtained from the experiment designs described in the Bureau's publication.

In the example given, let the letters A, B, C, D, E, F, and G stand for the seven factors, and let the subscripts 1 and 2 denote the two alternative conditions in which each of the factors may exist. Then the 128 possible experimental combinations are represented by the 128 cells of figure 1. The shaded squares represent those experimental combinations to be investigated if the experimenter wishes to measure only half of the possible 128 combinations. In the same way, figures 2 and 3 illustrate plans requiring only 32 and 16 measurements, respectively, instead of the full set of 128.

Naturally, the more measurements taken, the greater the resulting information and the greater the precision. The experimental plan calling for $\frac{1}{8}$ of the possible combinations can only be used for evaluating the broad effects of each of the seven factors. The $\frac{1}{4}$ plan, in addition, allows the interdependence of some of the factors to be determined. The latter plan could be of use, for example, when there is independent information indicating that the interaction between certain of the factors is negligible. The $\frac{1}{2}$ plan (fig. 1), on the other hand, not only provides information on the broad effects of each of the seven factors, but also permits evaluation of the interdependence among *all* of those factors. The only price paid for this information is a loss in precision. In many cases, especially in industrial experiments, this loss is more than compensated for by the saving in time and expense.

[1] Fractional factorial experiment designs for factors at two levels (1956), *National Bureau of Standards Applied Mathematics Series 48, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 50 cents.*

[2] The design of experiments, *by R. A. Fisher (Oliver & Boyd Ltd., Edinburgh, 1949).*

[3] The fractional replication of factorial arrangements, *by D. J. Finney, Ann. of Eugenics* **12,** *291 (1945);* A simple approach to confounding and fractional replication in factorial experiments, *by O. Kempthorne, Biometrika* **34,** *255 (1947).*

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, Volume **58,** No. 4, April 1957 (RP2749 to RP2754 incl.), 60 cents. Annual subscription $4.00.

Technical News Bulletin, Volume **41,** No. 4, April 1957. 10 cents. Annual subscription $1.00.

Basic Radio Propagation Predictions for July 1957. Three months in advance. CRPL-D 152. Issued April 1957. 10 cents. Annual subscription $1.00.

Research Papers

Journal of Research, Volume **58,** *No. 4, April 1957. 60 cents.*

RP2749. Comparisons of national radium standards. T. P. Loftus, W. B. Mann, L. F. Paolella, L. L. Stockmann, and W. J. Youden.

RP2750. Temper brittleness of boron-treated steels. Samuel J. Rosenberg.

RP2751. Optical and volumetric relaxation effects in glass following removal of high hydrostatic pressures. C. Weir, S. Spinner, I. Malitson, and W. Rodney.

RP2752. Reference wavelengths for calibrating prism spectrometers. Earle K. Plyler, L. R. Blaine, and Matthew Nowak.

RP2753. Tensile properties of copper, nickel, and 70-percent-copper–30-percent-nickel and 30-percent-copper–70-percent-nickel-alloys at high temperatures. William D. Jenkins, Thomas G. Digges, and Carl R. Johnson.

RP2754. Accuracy of the Cutler-Hammer recording gas calorimeter when used with gases of high heating value. John H. Eiseman and Elwin A. Potter.

Miscellaneous Publications

M220. Annual report 1956. National Bureau of Standards. 60 cents.

Publications in Other Journals

Achievements and prospects in auroral and airglow research. S. Chapman. The Airglow and the Aurorae. (Armstrong and Dalgarno, Belfast, Ireland) (Sept. 1955).

Note on persistent meteor trails. S. Chapman. The Airglow and the Aurorae. (Armstrong and Delgarno, Belfast, Ireland) (Sept. 1955).

The nondeviative absorption of high-frequency radio waves in auroral latitudes. S. Chapman and C. G. Little. J. Atm. and Terrest. Phys. (Academic Press Inc., 125 E. 23d St., New York 10, N. Y.) 10, 20–31 (Jan. 1957).

Analytical mass spectrometry. Vernon H. Dibeler. Org. Analysis. (Interscience Publishers, Inc., New York, N. Y.) **3,** 387–441 (1956).

Approximate theory on the stability of interfacial waves between two streams. Chan. Mou Tchen. J. Appl. Phys. (American Inst. of Phys., 57 E. 55th St., New York 22, N. Y.) **27,** No. 12, 1533–1536 (Dec. 1956).

A theory of long-duration meteor-echoes based on atmospheric turbulence with experimental confirmation. H. G. Booker and R. Cohen. J. Geophys. Research. (The Johns Hopkins Press, Baltimore 1, Md.) **61,** No. 4, 707–733 (Dec. 1956).

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Contents

NBS Publications (*continued*)

Some theorems about pr(n). Morris Newman. Can. J. Math. (Manager, Editorial Office, National Research Council, Ottawa 2, Can.) **9,** 68–70 (Jan. 1957).

Sources of transport coefficients and correlations of thermodynamic and transport data. J. Hilsenrath. Agard Selected Combustion Problems, II. (Butterworths Scientific Publications, 88 Kingsway, London WC2, Eng., 1956.)

The absolute photometry of the gegenschein. F. E. Roach and M. H. Rees. The Airglow and the Aurorae. (Armstrong and Dalgarno, Belfast, Ireland, Sept. 1955.)

The waveguide mode theory of VLF ionospheric propagation. J. R. Wait and H. H. Howe. Proc. IRE (American Inst. of Electrical Engineers, 33 W. 39th St., New York 19, N. Y.) **45,** No. 1, 95 (Jan. 1957).

Technique for monitoring tritiated-water vapor in air. C. A. Ziegler and A. Schwebel. Nucleonics. (McGraw-Hill Publ. Co., Inc., 330 West 42d St., New York 36, N. Y.) **13,** No. 1, 64 (Jan. 1957.)

The aurora in middle and low latitudes. S. Chapman. Nature. (Macmillan & Co., Ltd., St. Martin's St., London WC2, Eng.) **179,** No. 4549, 7–11 (Jan. 1957).

Invited discussion on the Haringx diaphragm theory. R. F. Dressler. Trans. Am. Soc. Mech. Engrs. (American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.) **79,** No. 1, 61–62 (Jan. 1957).

Screw thread standardization. A. T. McPherson. Standards Engrs. Soc. Proc. for 1956. (Proceedings of the 5th Annual National Meeting, Willard Hotel, Washington, D. C., Oct. 1956.)

Photoconductivity and photovoltaic effect in intermetallic compounds. H. P. R. Frederikse and R. F. Blunt. Photoconductivity Conference at Atlantic City. (John Wiley & Sons, Inc., New York, N. Y.) 414–426 (1956).

Radiative electron capture in cesium-131. D. D. Hoppes and R. W. Hayward. Phys. Rev. (American Institute of Physics, 57 E. 55th St., New York 22, N. Y.) **104,** No. 2, 368–369 (Oct. 1956).

Radiative orbital electron capture in vanadium-49. R. W. Hayward and D. D. Hoppes. Phys. Rev. (American Institute of Physics, 57 E. 55th St., New York 22, N. Y.) **104,** No. 1, 183–185 (Oct. 1956).

Spectrum of the C_3 molecule between 3600 Å and 4200 Å. Norman H. Kiess and Herbert P. Broida. Can. J. Phys. (National Research Council, Ottawa, Canada) **34,** 1471–1479. (1956).

The Government's bookstore. Lewis T. Milliken. The Capital Chemist. (The Chemical Society of Washington, Washington, D. C.) **7,** No. 1, 10–15 (Jan. 1957).

Mathematics.—Unimodular matrices of order 2 that commute. Karl Goldberg. J. Wash. Acad. Sci. (U. S. National Museum, Washington 25, D. C.) **46,** No. 11 (Nov. 1956).

Les recherches sur la structure des polymeres au National Bureau of Standards. Norman Bekkedahl. Revue generale du Caoutchouc. (Societe d'editions Techniques Coloniales, 42, rue Scheffer, Paris 16, France) **33,** 1129 (1956).

Accelerating effect of amines on polymerization of methyl methacrylate. G. M. Brauer, Ruth M. Davenport, and William C. Hansen. Modern Plastics. (Modern Plastics, Inc., 575 Madison Avenue, New York 22, N. Y.) **34,** No. 3, 153 (Nov. 1956).

Adsorption of gases and vapors on glass spheres. II. Two-dimensional condensation of oxygen. J. L. Shereshefsky and C. E. Weir. J. Phys. Chem. (American Chemical Society, 1155 16th St. NW., Washington 6, D. C.) **60,** 1162 (1956).

Bremsstrahlung polarization measurements for 1.0-Mev electrons. J. W. Motz. Phys. Rev. (American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.) **104,** No. 3, 557–562 (Nov. 1956).

Dental materials and instruments 1951–55. G. C. Paffenbarger, D. D. S. Intern. Dental J. (A. Sijthoff—Publishers, The Hague, Holland) **6,** No. 3, 299–322 (Sept. 1956).

Experimental proof for the existence of nonthermal rotational distributions of OH ($^2\Sigma^+$) in flames. Herbert P. Broida and Henry J. Kostkowski. J. Chem. Phys. (American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.) **25,** No. 4, 676–680 (Oct. 1956).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.